Poster: Distance Estimation Modelling in High Performance Localization System (HPLS)

Michał Marks, Andrzej Sikora
Research and Academic Computer Network
Wawozowa 18, 02-796 Warsaw, Poland
mmarks@nask.pl, asikora@nask.pl

Ewa Niewiadomska-Szynkiewicz
Research and Academic Computer Network
Wawozowa 18, 02-796 Warsaw, Poland
Warsaw University of Technology
Nowowiejska 15/19, 00-665 Warsaw, Poland
ens@ia.pw.edu.pl

Abstract

In this paper we present the results of our research concerned with the implementation and evaluation of a software system for wireless sensor networks localization – High Performance Localization System (HPLS). The system can be used to calculate positions of sensing devices (network nodes) in the deployment area based on known anchor nodes positions and collected measurements of distances between nodes in the network. During our work we had the opportunity to assess localization quality obtained for many networks with different way of gathering distance measurements. In the paper we compare three approaches: very popular method of adding Gaussian noise to real distances, link layer modeling method and RSSI data gathered from real-life deployments. The provided case study demonstrates the differences in localization accuracy depending on more or less realistic assumptions for measurements quality.

Categories and Subject Descriptors

C.2.1 [**Computer-communication Networks**]: Network Architecture and Design—*Wireless communication, distributed networks*; D.2.8 [**Software Engineering**]: Metrics—*performance measures*

General Terms

Algorithms, Measurement, Performance

Keywords

Wireless Sensor Networks, localization, measurements' error, HPLS, High Performance Localization System

1 Introduction

The objective of the location estimation systems is to calculate the coordinates (positions) of sensor nodes deployed in the domain. A large number of research and commercial location systems have been developed over the past two decades, and are described in literature [2, 4]. High Performance Localization System [3] is an integrated software framework (see Fig. 1) which supports sensor node localization starting from data gathering from real life deployments through signal propagation modeling to geographic coordinates calculation using various localization algorithms. The system was validated for various multihop network topologies through simulation and testbed implementation in our laboratory.

2 Distance measurements

In this paper we concentrate on data gathering and signal propagation modeling steps. In many theoretical papers the distance measurement errors are modelled by adding Gaussian noise to real distances. Moreover usually it's assumed that the measured distance is a real distance disrupted with Gaussian noise with mean 0 and standard deviation of 1 multiplied by a noise factor: $\tilde{d_{ij}} = d_{ij} \cdot (1.0 + N(0,1) \cdot nf)$, where $\tilde{d_{ij}}$ denotes the measured distance, d_{ij} the real distance and nf is an noise factor [1].

We don't have an experience with sensor devices utilizing ToA or TDoA techniques to measure spatial distances among them, however the testbed experiments with RSSI measurements indicates that typical value of noise factor equal 10% is underestimated. Since we decided to compare this simple Gaussian modelling with low-power link modeling based on *Link Layer Model for MATLAB* described in [5]. The difference between these two models is depicted in Figure 2 illustrating relationship between distance estimation error (DE) and localization error (LE). The range of distance estimation errors available for Gaussian noise model is marked with orange color, while the range for low-power link model (NBM model) is marked with green color. The localization and distance estimation errors are defined as follows:

$$LE = \frac{1}{N} \cdot \sum_{i=1}^{N} \frac{(||\hat{x}_i - x_i||)^2}{r^2} \cdot 100\%, \quad (1)$$

$$DE = \frac{1}{|\Phi|} \sum_{\Phi} \frac{|d_{ij} - \tilde{d_{ij}}|}{d_{ij}}, \quad (2)$$

where N denotes the number of nodes, Φ the set of all connections between nodes and r the communication range.

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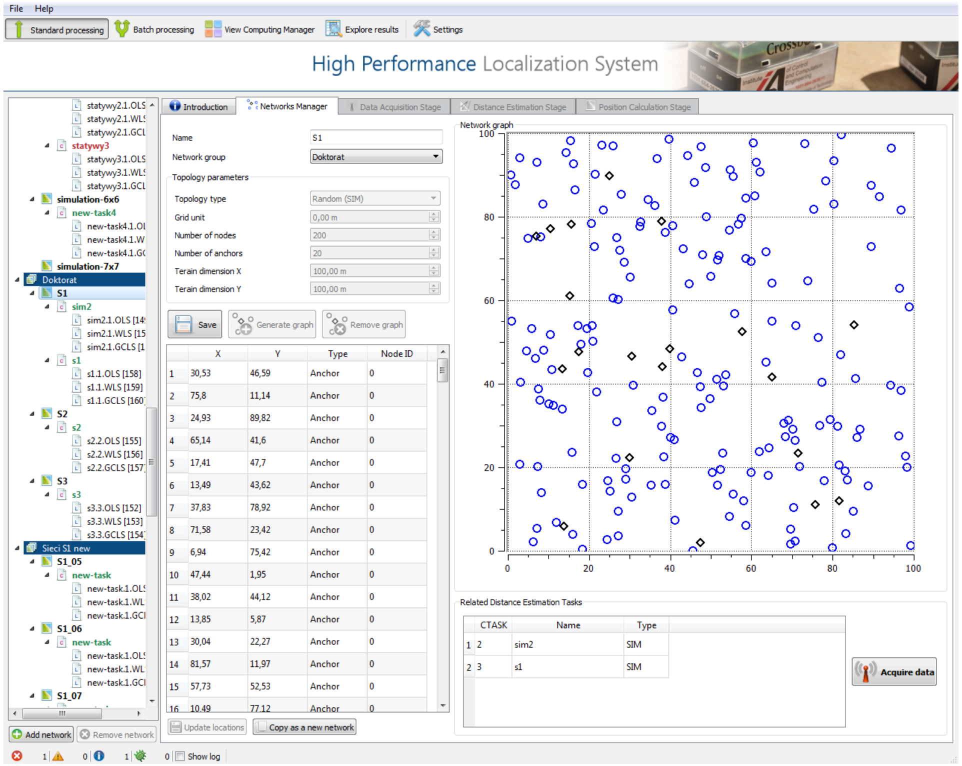

Figure 1. The HPLS graphical user interface.

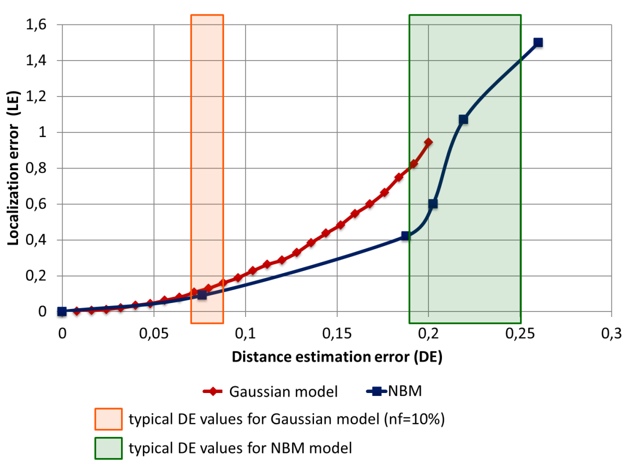

Figure 2. Localization error as a function of distance estimation error.

Conducted experiments show that in spite of the fact that NBM modelling is much more realistic than simple Gaussian modelling, the distance estimation error for NBM is still lower than distance measurement errors in testbed deployment – see Table 1. The presented results concerns network 7 presented in [3] (36 randomly deployed ADVANTIC CM3000 devices).

3 Conclusions

The paper presents the results of research realized in High Performance Localization System (HPLS) concerning distance estimation modelling. The basic results for two ways of distance modelling where evaluated and compared with data gathered from real-life deployments. The provided case study demonstrates the differences in localization accuracy depending on more or less realistic assumptions for measurements quality.

Table 1. Comparison of localization errors for different way of obtaining distance measurements.

Model	Localization error	LE in meters
NBM	0.14	0.31 m
Testbed	0.67	1.02 m

4 References

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